Chapter 11
Journal of 1785

Editorial Note. This journal covers a 3-week journey taken by Cavendish and Blagden, July 17 through August 8, 1785. The manuscript is copy of the original journal written by Blagden and subsequently discarded or not identified. The copyist was unfamiliar with the subject of the journal, as is evident from his occasional misreading of words. Cavendish made corrections in the copy, which are incorporated here without comment. Extra spacing between words denotes places in the manuscript where words were illegible to the copyist or where words or numbers were meant to be added.

Except in the case of a few missing letters in words, which are supplied in square brackets, inconsistencies and errors of spelling and grammar are retained. So too are capitalizations, with one exception. The letter "s," where it appears as the first letter of a word, is almost always capitalized in the manuscript, and since it is the only letter written this way, most capital "S"s are removed. Any illegible letters or editorial additions are indicated by square brackets.

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Sunday July 17th

Just to the left of the Road between Woolhampton and Thatcham, some of the Fossilwood Peat had been dug, and was then burning to all appearance for Manure.

Tuesday July 19th

In going down Nind Lane, from Wortley Turnpike, we soon got to the end of the calcareous freestone, and came into the stiff blue clay. The Farmers told us, that in digging, they first found pieces of blue limestone a little rounded, lying scattered

Henry Cavendish, "Computations & Observations in Journey 1785," *Cavendish Scientific Manuscripts*, Devonshire Collections, Chatsworth, X(a), 4.

R. McCormmach, *The Personality of Henry Cavendish - A Great Scientist with Extraordinary Peculiarities*, Archimedes 36, DOI 10.1007/978-3-319-02438-7_11,

irregularly in the blue clay, which they considered as an upper layer of the limestone beds, and called it the crop. Below the crop in digging they find successive layers of this Limestone, which, as they go lower, lies in more close compact beds, always with clays between, but where the Strata are very close, that clay is compacted into a hard Substance almost like Slate.—In ascending from this blue clay up the Fortworth ridge, we soon got upon a sort of Stone, looking like a gritty or coarse grained Limestone, which tried with an Acid, was found to contain not much calcareous matter. The dip of this Stratum was highest towards the Freestone hills, and amounted in some parts to 40° or 50° to the horizon. In descending the Fortworth ridge from Wickwar towards Splats hill, we came toward the bottom to the same stiff blue clay, in which the blue Limestone was lying as about Nind. In the quarries here, the Limestone was lying in the form of flat stones, some very thin, lying upon one another, with hard compacted blue clay between, having somewhat the resemblance of Slaty matter. Through some of the stones there ran veins of yellow matter seemingly mundic. The blue clay continued till we came near Hilsley, and there seemed to be nothing interposed between it and the beginning of the Freestone hills.

Wednesday July 20

In making the solution of Tin, Mr. Blagden used two parts of the Aqua fortis he had purchased to one part of Water. He drops the Tin in carefully, taking particular care, that the effervescence shall not be violent, otherwise a clear solution is never obtained.—If any Straws or pieces of Wood are in the Liquor during the solution, they are apt to make the mixture take fire, which entirely spoils it for dying, the Tin subsiding as a white powder: it also takes fire with the same effect, if the solution be made too violently. The Aqua fortis is prepared by adding to it a small quantity of Common Salt; and the Tin by being poured melted into cold Water, which divides it into thin irregular plates. No yellow fumes were perceived during the solution, nor anything like the smell of nitrous Air; the predominant smell was that of Aqua regia. We were told that when the solution heated much, it yielded yellow fumes, and became proportionably more turbid; and this was the case particularly when it took fire.—The solution, if well made, would keep many days, and even some Weeks, if the Weather was cool: The slower the solution had been made, the longer it would keep; and when the Operation had been nicely performed, the solution spoiled not by dropping any sediment, but by losing its yellowish, reddish or amber colour, and becoming pale and colourless. The powdered Cochineal was thrown in upon the Liquor in the boiler all at once, and floated on the surface, where it was suffered to remain, without being stirred into the Liquor; the solution called Spirits was then sprinkled on the surface of the Liquor at different Times, and in successive periods of the boiling, and the heat was urged at the same time till the surface broke, that is, till it boiled up violently. — It appears that the cloths are dyed without such preparations with a *mordant*, as is described by Hellot, the Tartar or whatever else may be necessary to fix the colours, being put into the boiler with the dying drugs. In dying the scarlet with grain, it is necessary that the cloths should not come into immediate contact with the copper boiler, other wise they are spotted. This is prevented by an osier frame in the boiler, cloths round the edges, &c. Alum entirely spoils the grain

colours, turning the composition to a dirty crimson.—The cloths are never dyed crimson with Cochineal alone, but with Spirits in the same manner as for scarlet, but less composition, not much more than half, and then the proper hue is given by means of Archall, which brings it down to the crimson, from a scarlet which is not very deep, or rather from a bright red. In dying Ora[n]ge, they put the Turmeric and Tarter into the copper first, and when the Liquor was boiling (simmering) though not boiling hard, they throw in the powdered grain, and afterwards sprinkled in the composition (Spirits) successively, so that all the ingredients were in the furnace at the same Time.

Thursday July 21

The fine and constant spring called Kinner Well in the road from M[r] Hale's house to Monk's Mill, had been previously found to be $50^{1}/_{5}$ by the Thermometer with a sliding Scale. We now tried the temperature of a bucket of water, taken up briskly from the well at the Lower house Alderly. By the same Thermometer it appeared to be 50¾; but by a Thermometer with a fixed Scale (supposed to be adjusted for the diameter of the tube) it was only 50¼ consequently supposing this last the most accurate, Kinner Well is only 49¾, and the Lower house well is probably the same, as the water may have heated a little in coming up. We then measured the rope with the bucket of the Well at the Lower house, and found it to be nearly 107. feet. We then measured by the barometer the height of the Lower house well top (as before) above Kinner Well, and it came out feet, consequently they seem both to be nearly the same level.

Friday July 22

At Frombridge we were informed, that in order to draw Steel or Iron wire, after they had annealed it down to the proper temper, they found it necessary to rust the rods or large wires, by means of sour waters, that they might not heat too much in passing through the holes. They first rub off the scales contracted in the annealing by means of a Mill, and then go to the operation for rusting, for which Sour Whey is much employed; still more to prevent the heating, they use much grease in the holes, which makes up into a sort of paste with the rust.

In making brass, they first divide their Copper, by dropping it melted into cold Water, which reduces the Metal into large irregular drops or lumps.—These are mixed up with about an equal weight of charcoal, but a much larger proportion of powder'd Lapis culaminaris, and the mixture is then put into a crucible (of Stourbridge Clay) so as to almost fill it, and then the crucible is put into a furnace, where the heat is immediately raised, so as speedily to reduce the Copper into fusion. In this state it remains 12 hours, and upon cooling the crucible a lump of brass is found at the bottom, about 1/5 of the quantity of the Materials employed. In making both brass and iron to wire, they are obliged to anneal each drawing; but with the brass it is not necessary to rub off the outer coat, produced in the annealing, which must be done with the iron. In making iron wire, they sometimes employ slit rods, but prefer certain rods made by hammering with irregularly lozenged Surfaces, from the Strokes of the hammer, as being of a more uniform texture, and drawing better.

In the slitting mills, both rollers were both turned by rack work, moved by the same axis. In the flatting mills, two rollers were turned by 2. separate water wheels.

At the Tunnel cutting for the canal at Saperton, we observed that the freestone brought up was partly yellow and partly blue, the same piece of stone being often tinged through of a blue colour, not exactly in the direction of the layers, but approaching to it. The different layers of freestone had in many places layers of clay interposed. The shafts sunk down the Tunnel were, we thought, remarkably near one another: the deepest now made, is 35. yards; but nearer Saperton there are to be shafts as deep as 60, we were told. The Tunnel itself was by estimation from 20. to 24. feet high; arched and walled with bricks: only about 40 yards are compleated.

At Stroud we were informed, that the old Canal had not yet paid any Dividend to the Proprietors, and that scarcely any thing but coals were brought up it, at the rate of 3^{s}/[?] a ton. The new cut extends from Stroud near 5 Miles to Chafford Prince, so as to be navigable; but no further as yet.

Saturday July 23

At Stone Bench the head of Tide passed at 9^{h} 50′ A.M. by the watch[. L]ast night at Alney, it came up nearly at the same time p.m. At Alney it made a good deal of noise before it came; at Stone Bench but little. The tide passed this Evening at Newnham soon after 8 in the Evening.—It rose with great rapidity, and after the waves caused by the first coming, had entirely subsided, perhaps half an hour or more after the first head, it seemed to rush up again with renewed violence, so as almost to form a head. We were told, that the tide, though earlier than we had expected it, did not come sooner than it ought: that in spring tides, the interval between each tide, seldom exceeded ¼ of an hour, and that it was this Evening about one quarter of an hour later than it had been in the Morning. A person present said, that about 5 or 6 years ago, the Channel of the River, which used to run close to Newnham, had shifted to the other side, and now ran equally close to Arlingham.

Monday July 25

The furnace at Pentyrch not being in blast, we could only examine the forges. They are of 2 kinds, the Finery and the Chafery. In the Finery they make use of Charcoal only. A pig of iron is put on a hearth in the midst of a heap of burning Charcoal, and the blast of the bellows directed upon it, as it softens and partly melts, it runs down into the lowest hollow part of the hearth, the workmen stirring it all the while, till at length it is collected in the hollow as a soft tenacious lump, which can be taken up with the proper pincers. At the front of the hearth is a hole for the scoriae to run out. The lump while hot, is at the proper time taken up with a pair of large iron pincers, out of the Charcoal, and struck with iron rods all over the outside, to beat off all the Scales and adhering foulness which can be separated in that manner. It is then laid under the hammer, weighing 6 or 7. C^{t} weight, the first strokes of which, besides making a large number of hot scales fly off to a distance, is to make a white hot fluid matter run out of different cracks of the surface, some times in considerable quantities. From some of the cracks also a bluish light flame issues, often to the height of 2. or 3. inches. This flame comes out without any strokes of the hammer, though more when the lump is under the hammer. This lump is then

beaten with the hammers till it is reduced to an oblong form, ab^{t} 20. inches long and 4 inches thick, called half-blooms. These are then heated again in the same fire on the hearth where the pig is melting, and when white hot, are again brought under the hammer, and reduced, by beating in the middle, to a long bar, about inches in length, terminated at each end by a knob of 8, or 12. inches, being so much remaining of the original half-bloom. In this operation one end of the half-bloom is but little heated, as it sticks out of the fire, and affords a hold for the pincers to move it round in the fire, and at length to take it out. After these blooms are finished they are removed to the Chafery, where the knobs at the end are drawn out, and the Iron is fashioned into various utensils. All this is done with pit coal; but only particular veins of it are fit for this purpose. The knob at the end is heated in a hearth like that of the finery, and when white hot is laid under the hammer, and beaten till it is drawn out even and similar to the original bar of the bloom, and it is found to be in all respects equally good Iron.

The Scoriae of different kinds are heated up again in the Charcoal fire with the pigs into those lumps, of which the half blooms are formed.

The shape of the hearth at the finery is as follows: It consists of an oblong pit, formed of cast iron plates, about 2 inches thick. The pit is 2 feet 4 inches long, 1 foot 6 inches broad, and about 7. inches deep. In the front plate is a hole even with the bottom plate, which they tap by thrusting an iron into it, to let the Scoriae run off; and at the bottom of the front plate is a notch, lower than the under side of the bottom plate, through which an iron is thrust to heave up the bottom plate when necessary. The bottom plate does not come quite home to the front plate, for which no reason was assigned, but that it was unnecessary for it to be close; the distance was about 4 inches.

The weight of each lump, as it melts down from the pig, is about ¾ of an hundred. The pig rests upon the edge of the back plate, and the nozzle of the Bellows on the edge of one of the side plates, much nearer the back plate than the front plate, and just under the projecting end of the pig. As the pig melts, the matter collects at the bottom of the hearth, and does not come into liquid fusion, till it is among the cinders, or Scoriae, which the workmen consider not only as bringing it to the quality of tough wrought iron, but even as necessary to melt it perfectly. After being stirred, and as it were kneaded some time with the Scoriae, it ceases to be in liquid fusion, and becomes that tenacious lump, which they take out with pincers to put under the hammer. An half bloom is commonly about 20. inches long and 4. inches thick. The Blooms are of uncertain length, according as they are drawn out into a longer or flat bar: the former is about 4, the latter only 2 feet, besides the knobs at the end, the longest of which is near a foot, and the shortest about 7 or 8. inches. The firework sparks fly off in all parts of the operations in the Finery.

In the Chafery the hearths have no front holes for the Scoriae to run off by, but the refuse matter collects at the bottom into masses they call *Mosses*, which are taken out every 12, or 24. hours, when they make up the fire afresh. Those in the Chafery hearth, worked with pitcoal, contain much iron, but are not found worth working over again, so that they are absolutely refuse; but when the Chafery hearth is worked with Charcoal, the Mosses contain no iron. The former ones are round

Mosses, of the size of a large Man's head, hollow in the middle, and open at top, very spongy and rusty. In the Chafery when they use Charcoal, it is commonly small and dusty, which they call brain, and this works up the Blooms & with less loss.

At Newnham the Cliffs consist of a red stone partly calcareous, but leaving a good deal of undissolved matter, divided by thin seams of whitish wax-coloured shivery stony matter, which did not dissolve (in Aqua fortis) and appeared to be argillaceous.

When we got among the Hills about Pentyrch Works, they were found to consist of a reddish Lime Stone, laying in Layers which dip from S. to N. the whole Stratum very thick; the angle to the horizon at least 45°.—Proceeding northward we came to a blue shivery clay Stone, in some parts soft, deeper down very hard, in which both the Iron Stone and coal seem to lie; or at least at Pentyrch Church the Lime Stone was as at the cliffs above the works; then we passed a Lane, and the first Stone, as we ascended again toward the Garth, contained no calcareous matter. In the Valley between the Garth and the hills of Pentyrch, were the Coal pits. In the Lane, ascending toward the Garth, where the first Stone not calcareous was found, the layer dipt very much, and apparently in the same direction as the Lime Stone of Pentyrch hill. In digging the Coalpits, they pass through nothing but the blue shivery claystone, which the lower they go, the harder it is, till near the coal it is quite a Stone; but on being brought up, and exposed to the Air, it presently shivers to pieces, and moulders down.

On Caerfilly Common we had the calcareous hills to the S. The common itself consists chiefly of the blue shivery clay Stone, which also becomes harder the deeper they dig, till at length they come to a seam of Iron Stone, from 6. inches to a foot thick, with pellets or nodules, interspersed above and below the seam. In other places of the Common, in digging through the blue clay, they come to coal. Under the seam of Iron Stone; they have the same blue clay stone as above it. They have 5 different seams of Coal with the blue clay stone interspersed. The seams of coal are from 2 to 4. feet thick each.

At the furnace we saw three different kinds of Iron, mottled, dark-grey, and bright-grey. Of these the mottled melts the easiest; bright-grey next easiest, and dark-grey most difficult. The mottled will not make good tough Iron by itself, but either bright- or dark-grey will. Light-grey is always used by itself; but dark-grey is more frequently mixed with a little mottled, because it is very slavish to work, and of difficult fusion. The proportions are one ton of mottled to 3 of dark-grey. The mottled on breaking, looks more like light-grey, but has some white spots, especially toward the edge of the fracture. The general ground seems granulated, but the spots look like crystallized plates broken edgewise. The light and dark-grey are both granulated, but the former exhibits finer grains in the fracture, than the latter. In a Ton of pigs 28 lb is allowed for sand; and then 4 Tons of pigs, make 3 Ton of blooms 21. C^{t} w^{t} to the Ton. To produce a Ton of Bar Iron, 21. C^{t} w^{t} of blooms is allowed, and 22. C^{t} of half blooms. The whole produce from 4 Ton of pigs then is 3 Ton of Bars, 20 C^{t} w^{t} to the Ton. The greatest advantage is to have the Iron bright-grey, shews that the proper proportion of ore to the charcoal in the furnace is used; if too little ore, it then becomes dark-grey, if too much, it becomes mottled, and when in excess, the furnace cools, and sometimes the mass congeals and spoils the

furnace, so that they are obliged to take it down. Producing dark-grey, they call a low furnace, mottled and tending to congeal is raising the furnace high.

At Pentyrch they were putting a new hearth in the furnace. The hearth-part, which is the part in which the ultimate fusion of the metal is effected, is nearly square, about 2 feet in length and breadth, and perhaps 4 feet deep, built very solid. The hole for the blast was on the left hand wall, exactly in the middle between the back and the front, and about 18. inches from the bottom. The front is made by what they call a temp, which reaches from above to about 18. inches from the bottom; and the lower part of the outer front is a plate of Iron 2 inches thick, provided with a large notch in the top edge, and two arms on the right hand side. This Iron plate is put close home to the left hand wall, but leaving space between it and the right hand wall, which in working is stopped up with sand. The arms above mentioned reach to the right hand wall, into which they are fastened. Between them the poker is thrust, when it is necessary to stir the melted matters; and the furnace is tapped, to let off the melted metal, by removing the sand which fills up the interstice between the right hand edge of the front plate and the right hand wall, close to the bottom; when the Metal discharges itself through a gutter made in sand, into a series of parallel side gutters: the middle gutter and Metal congealed in it, being called the sow, and those on the sides each a pig. Immediately above this square part, the furnace spreads on each side at an angle of between 30° and 40° to the perpendicular, and after enlarging in this manner to a certain height, it again contracts to form the Mouth at the Top, by which the Furnace is fed. The parts that rise up immediately above the square hearth are called the *Bosses*.—When the Furnace is working, the whole load of Matter up to the Mouth is red hot, as we were told. After tapping the Furnace, they cease blowing some time, about half an hour, to get out the *Scoriae* and clean the hearth; after which the blast being renewed, the Operation is found to have been in no respect injured by the cessation. Round the hearth they make what is called Air pipes, forming a hollow communication, from the external Air at the Water wheels, about even with the bottom of the hearth, where there is one hole, to the Air in the casting house, where there is another hole in the wall from the right hand side of the hearth above, level with the top of the cast Iron front plate. The use of these we could no otherwise learn, than that the Furnace would not work so well without them. Each hole, and we suppose for the whole length of the communication is about 2. inches square. The hearth is built of a sort of Plumpudding stones, of which we saw great numbers about Pentyrch loose in the channel of the Taaf.

Wednesday July 27th

Visited the Works at Mellengryffyth. The Forges, &c. seemed the same as at Pentyrch. For making plate tin, the Iron is first drawn out into long and broad bars, which are then cut into slips nearly of the breadth that the tin plate is to be. These are then drawn out between rollers. At last they come to be rolled 4 sheets thick, and are then cut at the edges all the four sides of the square, to be made smooth, and then the 4. plates are separated from each other, which requires some force, as the cohesion is considerable. Each plate is next dipped separately in Spirits of Salt, being previously bent in the middle, and laid in a kind of Oven, to

be made red hot; they are then taken out, suffered to cool, then bent back as smooth as they will readily become by the hand, and several of them being laid together, they are struck with great violence by a Man on an iron Anvil. By this operation the general scale or coat of rust, formed by the Spirit of Salt and the heating, is beaten off, and the plates rendered of an uniform though roughish surface; in some places discoloured of bluish or yellowish brown, which we were told was not a scale, and had no bad effect in the tinning. Each plate is next passed through a pair of rollers to make it smooth and even, and it is then steeped a proper time, half an hour more or less, in a sour Liquor, made of bran and water, fermented. From this Liquor, it is put in common water, and is thence carried immediately to the melted tin, without being dried. The tin is melted in large boilers of a proper depth to take in the whole plate, and its surface is covered with tallow or hogs Lard; but these being now dear, they were trying fish-oil and found it answer. The iron plate is taken out and turned, and passed again into the Tin several times: so that the whole operation, till the surface be properly covered, takes up about half an hour. The tinned plates are then scoured with bran, till they have acquired a proper polish. At the time the iron plates are steeped in the sour Liquor of fermented bran, they are well scoured with sand, &c. so as to clean the surface perfectly.

At this Work they make bolts for ships by welding together the shavings of the tin plates, by means of a hand hammer, and they consider the Iron as tougher than any solid piece would be. The inside parts are not compacted into one mass, but only cohere, and they are thought less likely to break, than if they were one mass, besides that the iron would be much burnt, before they could be so compacted.

Thursday July 28th

Having heard that the blue Lyas Limestone was at Penarth point, we went thither. After passing the Salt meadows near Cardiff, we came to a hill which they call Lecquith; we found it lying in Strata nearly horizontal divided by thin seams of blue indurated clay; the whole hill seemed composed of these alternate seams, & probably contained as much Limestone as clay. When we came to Penarth Point, we found the cliff consisting of the red Clay stone, with seams or veins of white clay stone, as at Newnham, above which the Lyas with its clay was laid, composing the upper part of the cliff. A[t] the point some of the thin seams between the red Stone were of Gypsum or Alabaster.

Friday July 29th

The Furnace at Pentyrch is 26 feet, but the Funnel reaches much above it, and other Furnaces are much higher. The bottom of the hearth is narrower, and proceeds upwards widening a little, so that the Temp-stone is supported by the inclining sides. In wet weather they can use to work the furnace only one measure of the wet charcoal to 6. of dry; but when the weather is dry, they can use 2. wet to 7. dry. In the forges they do not regard whether it be wet or not, and are frequently wetting it, to prevent the iron from cracking, from the difference of temperature between the parts of the Bloom out of the fire, and those in it.

At Merthyr a new Furnace with Machinery is just erected by the Messrs Humphries. The blast is given by means of a fire engine on the old construction, the

cylinder 40. inches diameter. At the further end of the beam, a piston was worked in a cylinder 6. feet in diameter, which forced the air into two cylinders, one on each side: from which went pipes that united in a reservoir, from which the blast was conveyed by proper pipes to the Furnaces. The covers of the side cylinders were loaded with a weight equal to 4 inches of quicksilver. When these covers, which were moveable within the side cylinders, rose to a certain height, by the Air forced in underneath them, they raised a frame which opened a valve, that afforded a discharge for the superfluous Air from the middle cylinder in which the piston works. The Engineer, whose Name is Birch, supposed that half the Air escaped this way; and it is intended to convert this Air to the working of a Forge. The piston of the middle cylinder, which was 6 feet in diameter, made a stroke of 5 feet, 12 times in a minute. The pipe which let the Air into the Furnace, was fastened to the main pipe by flexible leather, so that it could be pushed in or out, and otherwise guided.

The Furnace was like M^{r} Lewis's at Pentyrch; but the boshes reached up not more than ⅙ or ⅕ of the way from the hearth to the mouth where the Furnace is fed; and the width of this Furnace seemed much less in proportion to its height than M^{r} Lewis's. The width was 12 feet, the height 60. The Air pipes extended round, under, and up, in all directions, and are intended to prevent the Furnace from bursting, by the Air and Steam, when it comes to be heated. This Furnace had cracked toward the top, which was attributed by many to its having been heated too soon. They use 3 ton of Coak to make 1 ton of pig Iron, and the ore used, is entirely the stone of the surrounding hills. The casting we saw, consisted almost entirely of plates for the Anglesey Copper works. They were oblong, weighed nearly 1 C^{t} w^{t} had 2. holes toward one of the long sides, and a protuberance between them, and were about 1/2 an inch thick. The holes are intended as handles, and the protuberance to keep the plates apart, when they are laid in the Copper water. They were going to cast a hammer beam, that is, the axis by means of which the hammers in working are raised up.

There are several veins of coal in the neighbouring hills, with the blue clay above, beneath, and interposed. The bed of Iron ore, of which there is only one, lies underneath the coal. The veins often failed, and were found again at another level. The seam of Iron ore is attended with pellets and nodules, as in the Caerfilly Seam. They coak the coal by laying it in a large heap, several times broader than deep, and then light it at the top. When the flame has spread something more than half way over, which it does in 6, 9, or 12. hours according to the nature of the coal, they cover it up with ashes; but the heaps or pile being hollow underneath, by a foundation of large coals laid upright and separate from each other, the fire spreads at bottom, after it is smothered on the upper surface, sufficiently to coak the whole heap. The ore is roasted in the same manner as lime is burned. Some of the kilns in which it was roasting afforded a smell of Sulphur, in others scarcely any thing could be distinguished but the common smell of coal.—At the top of the furnace in which the ore was melting, though 60. feet above the hearth, the flame was very strong, M^{r} Humphries prefers these high and comparatively narrow furnaces, because that construction makes a greater draught of air in the middle parts, and consequently a stronger heat.

The Method of tapping at Mr Humphries's Furnace, was exactly like that described by Mr Lewis, by removing the sand at the side of the front iron plate, close to the bottom of the hearth; except that in his Furnace, the interstice filled up with sand is at the left hand side of the hearth. As soon as all the Metal had run out, they began to clean the hearth, by removing the Scoriae and congealed matter with iron hooks and pincers, and the blast was suspended all this Time, perhaps a quarter of an hour, till the hearth was sufficiently freed of impurities. Mr. Humphries informed us, that the Materials, tho' much heated, and almost ready to melt in the body of the Furnace, do not really melt till they come under the blast; but immediately as they are acted upon by the Air, run down quite fluid. In consequence of the crack, in the top of this Furnace, the flame forced itself out at the holes, that had been left as Air holes near the Top.

Saturday July 30th 1785

This morning we went to Cyfarthfa Forges, Mr Bacon's, now let to Mr Tauper, about a Mile from Merthyr. Here coak iron is reduced to malleable iron, without charcoal. The pigs are first melted down in a hearth[1] and stirred till they become a lump, as in the charcoal works; they are then put under the hammer hot, and reduced to flat plates in general about ½ an inch thick, of an irregular shape, and rough cracked irregular edges. These plates are then broken under a hammer into pretty large lumps, which are laid in a heap, and kept moist by water dropping upon them. We found them blackish on the outside, with spots of rust, and at the fractures of a granulated texture bright light colours, but also in places much rusted. The small stuff that was collected in the hearth, they washed with water, and then laid it by separate. Afterwards the broke lumps are put into cylindrical pots, made of refractory clay near a foot deep, with a certain proportion of the washed small stuff, which served as a flux. There is no other addition, and the surface is not covered. The heat is not urged for the metal to melt, but so that the different pieces may be welded together, which happens by their sinking down into a sort of mass, and contract so as to leave the sides of the pot, which usually cracks and is easily separated, This mass is then formed into a half-bloom, a bloom, &c. as in the common forges.

In proceeding up the Valley of the Taaf, toward the Van, the Strata were not much inclined. At first we had nothing but the same rock as about Merthyr, which seems a sort of Clay-stone, or at least is a hard Stone not calcareous. (Much of the Stone about Merthyr, of the same appearance nearly, is soft and crumbles.) Some Miles from Merthyr we got to Limestone, which composed several of the rising hills, and lasted for some miles but a few miles before we reached Pont-y-Taave. At the bottom of the Van, we came upon a sort of slaty rock, which lasted all up the Van, with some difference of appearance. Toward the Top of the higher hills on each side of the Valley of the Taaf, there were Strata of stone of a different appearance, which Mr Humphries said was Lime Stone, and this seemed to form the upper Strata of stone on these hills.

[1] These hearths are nearly of the same form as those in the charcoal Works, but with some peculiarities, which the Agent told us were known only to the workman.

Sunday July 31st 1785

On the road from Brecknock to Abergavenny, we had lime kilns on the right, near the top of the high hills on the S. side of the Usk. The Sugar loaf mountain seemed to be the same stone as about the Van. Many miles before we reached Monmouth, the soil had the same red appearance as about Newnham and Chepstown.

Tuesday August 2d 1785

In ascending Malvern hill at Wytch from Ledbury, we saw Lime Stone rising up along the hill, to the right, just at the foot of the down part, which they were burning into Lime. The highest point of the hill, is immediately above Malvern village. In ascending we saw rock projecting in several places, which was a sort of coarse Granite, below almost resembling a very fine plum-pudding stone, but near the top composed of much finer parts or grains

At Birmingham we were informed by Mr Withering and Mr Watt, that the part of the road through which we descended off the [−−]cky on the northside, when fresh cut, appeared evidently to be a granulated Quartz.

The Machine for twisting the handles of horse whips, is so constructed, that the bobbins can move only one way, as the Machine is turned backwards and forwards; but they slip over one another alternately in succession.—When the bobbins rise up to a certain height, a catch is set loose, which suffers the thread to unwind from the bobbin half a revolution.

The great inconvenience complained of in the needle Manufactory, is their warping in hardening. In that case they must be made straight by a stroke with the hammer; but this leaves an impression, and the needle is always the worse.

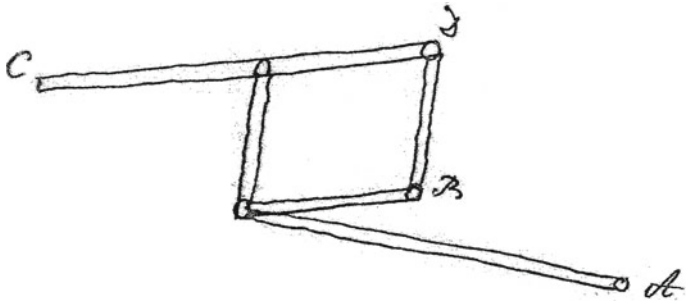
In the rolling plate Manufactory at Snowhill, a circular motion is given by means of the steam-engine. A bar of iron is fastened to the beam of the Steam engine, and at its lower end turns a crank, which gives motion to a wheel, communicating with the rest of the Machinery. In order to keep that in motion, when the crank is at its upper and lower points, it moves a wheel by rack-work, which makes its revolution in half the Time; and to one part of this wheel a heavy weight is fastened, which tends to accelerate motion most, when the crank is at the upper and lower points, and retard it, when the crank would give the quickest motion. It was invented, or at least the patent for it obtained, by a Mr Picard, who has sold it to the present proprietor; but Mr Watt claims the original Idea. In order to make the silvered plates draw, it is necessary to forge them, previously heated, before they are first put between the Rollers. In order to fix the plate of silver on the plate of copper, they make the surfaces of both exceedingly clean, and then wet them with a solution of Borax. They are then put into the fire, and the workman watches the time, when the edges of the two plates in contact melts. Whenever that is observed, he takes them out of the fire, and they are found perfectly fixed to one another: not so however as to bear being rolled, till they have been again heated and forged with a hammer.

Wednesday August 3d 1785

At Soho. The pieces of steel which are inlaid into the Bath metal for buttons, are made of a steel very highly converted, so that it can be hardened by a very slight heat. Some steel is so converted, that it can be hardened with a heat scarcely sufficient to make it slightly red hot; but that kind of steel has not much strength.

The fashionable excellence of gilt buttons is that they may look red, much like copper. For this purpose the gilt button scarce polished up, is dipped into a solution of some salts, amounting as Mr Watt said, to a kind of Aqua Regia. It is then set on a part of a stove, which seems to make it obscurely red hot, and then is thrown into cold water. Upon being afterwards burnished, it looks so like burnished copper, as not to be distinguished even by workmen, without applying Aqua fortis.—The very fine black polish is given to silver by burnishing it with Haemalites; nothing else will make it so perfect.—Filigree work is fastened in by strewing sodder with Arsenic over the surface, and melting it with a Blow pipe, when it is absorbed at the parts in contact, without filling up the interstices meant to be left hollow.

Mr Watt's new method of giving a circular motion by the Steam engine, is by making a small wheel fastened at the bottom of the bar, suspended to the beam of the Steam engine, pass round a larger wheel, without revolving at all on its own axis. The centers of these two wheels are connected by a lever, keeping the small one constantly at the circumference of the large one. The effect of this is, that the larger wheel performs always one revolution, and as much more as corresponds with the number of teeth in the smaller wheel, while the latter is passing once round the circumference of the former.



This figure represents the manner of making a rod, moved by the beam of a Steam engine, perform its motion up and down vertically in a straight Line, without the help of a circular arch and chains. CD is the Beam of the Steam engine, C. its center, A. a fixed point, and B the point which is to move vertically in a straight line.

Mr Watt mentioned, that having found that some steam is condensed in the cylinder of the Steam engine, tho' surrounded with steam, he made an experiment to discover what happened. He threw steam into a Glass vessel close at top[2] and found that upon making the Vacuum some of the steam condensed on the sides of the Glass Vessel; and having heated the sides of this Vessel, so that none could condense upon them, he observed the condensation to take place, so as to render the Steam visible in the middle of the Glass vessel; that is, when the sides were much heated, no cloud was perceived; but as they cooled, a cloud began to appear at each Vacuum,

[2] By making it communicate with that part of the cylinder of this fire engine in which there is alternately Steam and Vacuum.

in the middle of the glass vessel; and when any parts of its sides were sufficiently cooled, the steam then condensed on that cooled part.

Mr. Watt thinks to have ascertained by experiment, that the less heat water is converted into steam with, the more latent heat it requires to assume the elastic form; more even than the difference of the sensible heat: for instance, that water converted into steam under a pressure that suffers it to take that form at 100, contains more heat, sensible and latent taken together, than when it is converted into Steam under the whole pressure of the Atmosphere at 212°. He states the difference at 100. or more. Mr Watt considers the heat of steam at 212. both sensible and latent, as near 1160, reckoning from *0* of Farenheits scale; therefore the heat absorbed in the act of conversion from water into steam, is 1160 − 212 = 948. He considers the Density of the steam of boiling water at 212. to be 1800. less than that of water.

Thursday August 4th 1785

In the road between Wednesbury and Bilson, going from Birmingham to Woolverhampton, we saw a coal pit hot and smoking, which not many months before, we were told, had been burning. The Steam had the appearance of coming from the Top, but really came from the bottom, and continued transparent all the way up, being condensed, and so becoming visible, when it came near the top in contact with the cold air. Several other pits in that neighbourhood are in that same state, some of them throwing up fire or flame, which is visible at night many feet above the Top. The road here about is mended with a red substance like potsherds, being the clayey matter about the pits, burned by this internal heat.

Between Wolverhampton and Shifnal, great part of the way we saw lying by the side of the road for the purpose of mending it, both large and small stones of Granate, all rounded in the manner of pebbles, many of them seemed much to resemble the Granate we had found on Malvern hills. The red soil continued with little interruption all the way to the wooden Bridge over the Severn.

The place where Mr Wilkinson's Iron works are carried on, near Broseby, is called Willey.——This Iron is all made with coak, from ore and coal found on the spot. The ore is of 2 kinds, called *pinny* and *flinty* ore: the latter harder than the former; but both he considers as a clay Stone, impregnated with Iron. Both ore and coal lie in clay, the former usually over the latter, when both are found together; but in some places, one in particular he mentioned, they interchange, the Seam of Iron ore running under the coal. Mr Wilkinson described to us a fault in the Seam of coal near his Works, which he called a hog's back. It means an interruption in the Stratum of coal dipping according to the usual direction; but when the Stratum is found again, that part dipping in a contrary direction: so that if a Line were drawn from the bed on each side of the fault according to the angle of inclination, the two lines would meet one another in an angle in the middle, raised above the surface of the earth. He said the regular and usual dipping of the Strata was a little to the Southward of East. He spoke of a place in Staffordshire, where after a fault the order of the seams of coal was inverted, those lying undermost, which before the fault were uppermost. The Limestone he uses as a flux, is of a lightish colour, inclining to yellow, and has very distinct marks of extraneous fossils, shells, coralls, &c.

He has two Steam engines, one for the blast, and the other to raise Water to work the hammers. The cylinder for forcing the Air into the reservoirs, is 72 inches in diameter. The piston in it, is worked up and down by the Beam of the Steam engine, and I believe he said makes a stroke of 7½ feet. From this cylinder pipes go into reservoirs made of brick, open at bottom, and surrounded with a column of water,[3] by the pressure of which it is meant, that the effort of the air to escape, should be uniform. Out of these Reservoirs, for there are two of them communicating together, pipes are led which convey the blast wherever it is wanted. The Air was let into the furnace in the same manner as at Merthyr. The furnace is 25. feet high, it was all flaming on top. He said the height of a Furnace should be determined by the nature of the ore, particularly its more easy or more difficult fusion. He is of opinion that the ore melts and runs down a considerable way above the point where the blast comes into the furnace. He said the blast might be suspended 16 or 18. hours, without spoiling the Furnace.

In the Finery he had a current of water under the bottom plate of the hearth, but conceived it to be of no other use than to keep that plate from melting. The pig is here melted down with coak into a lump or loop, which is beat under the hammer into flat plates about an inch thick, with irregular edges. These are afterwards broken with a hammer into irregular pieces, and then picked, to separate any metal which may not have been properly refined. These pieces, with the small bits broken of[f] from them in the hammering, the latter previously washed, are put into an earthen pot, and kept in a fire, 3, or 4, or 5 hours, in the course of which Time they run together into a mass, tho' without coming into fusion, it is rather as a sort of welding, The pots soon break, and some fluid matter runs off, which is one sort of finery cinders. When this lump is taken out of the fire in the pot, it is again hammered, and another quantity of similar finery cinder is separated from it. The small stuff or bits put into the pots with the large pieces, are what is broke off in hammering out the flat pieces or cakes; for the original lump does not bear the hammer like iron made of charcoal, but breaks and crumbles very much, this forming the small stuff in question. M^{r} Wilkinson employs 31. or 32 C^{t} w^{t} of coak pigs, to make one Ton of Iron. The first refining reduces the quantity to ab^{t} 25. C^{t} w^{t} and the second that from the pots, reduces the 25. C^{t} w^{t} to 20. The pigs do not come into Nature, as the Term is, till they have discharged a large quantity of finery cinders: after which the mass puffs up and becomes spongy, like Fermenting, and has then assumed the Nature of tough Iron, tho' still as yet but imperfectly.

The forged Iron M^{r} Wilkinson here makes, is chiefly used for nails; it is not so malleable and tough as the Charcoal Iron made in England; but that M^{r} Wilkinson imputes to the nature of the ore, and says, that this Coak Iron is better than it could be made by Charcoal with the same ore; the reason he assigns is that more of the original pig is worked away.

Friday August 5th 1785

We went to M^{r} Rathbone's Works, at Coalbrooke Dale, where the Iron Bridge was cast. They have two Furnaces, one a little below the other. The upper Furnace,

[3] The pressure of this, he said, was equivalent to 2. lb on each square inch.

the smallest, is 25, or 26. feet high, and 12 feet wide at the Top of the boshes. It flamed at Top like the others we had seen. The blast was given by two cylinders, without any regulator, only a comparatively small box of Iron, into which the pipes from the two cylinders united. Hence a pipe conveyed the blast directly to the Furnace, and was furnished with flexible leather as usual.—All the motions were produced by water, raised by a Steam engine from the depth of 101. feet. The Engine was of Watt's construction: but in the little dish which sits upon the Collar in which the shaft of the Piston works, greatest part of the Liquid was water; but with some thickness of oil swimming upon the Top: and the Agent told us, that a small quantity of water getting down into the Cylinder, did not injure the motion; but rather served to keep the piston tight and in good Order. W[h]en the Engine began to lift, it made a short pause, in the manner of a common Engine, and it worked remarkably slow 12. or 9. times in a minute. The works extend near a quarter of a Mile, and the same Water serves all, seeming to have about five successive falls: then from a dam at the end of the works, it is carried by a level to a pit under the Engine just 101. feet deep, whence it is raised by the Engine into the upper reservoir, and so again makes the round of the Works. At the Furnace they employ three sorts of ore, called *white flats*, *pinny*, and *ball*. These lie intermixed with the coal in Strata of clay, and are found from 2 to 3 miles up the country. They have lately dug from near the Iron Bridge, a harder sort of ore, which lies under the coal and all the other measures, and is supposed to be richer than the former ones. They had desisted from shingling at the forges for want of water, but wer[e] trying an experiment of working up the broken pots, kettles and other pieces of cast-Iron, by merely heating them with coal in the shingling Furnace without pots. The Iron so made, did not prove very good, but was manufacturing into stampers, for which purpose, they said, it was good enough. There was a Mill for boring Cylinders. A square Iron box on a long shaft of the same Metal, received an Iron wheel of near the diameter of the Cylinder to be cut. This wheel had four pair of notches, each two near together, but each pair at intervals of a quarter of a circle from each other: Into one of each pair were fastened the 4. cutters employed, and the other of each pair received a piece of wood, of the same width as the cutters, so as to fit exact in the Cylinder, but rather behind the fore edge of the cutter, that it might only touch parts which had been cut. The use of these pieces of wood was, to make the Work go smooth, and prevent jarring.

About half a Mile below the Iron Bridge, is a Manufacture of Coal Tar, belonging to the same Company. The Coal to be distilled, is put into chambers, built of fire brick, in the form of plates, and a fire is made under them, which drives the vapour through communication pipes of brick into a common gallery, or chimney, nearly horizontal, which is conveyed round, and terminates in a Reservoir for the Tar or oil, over which the water swims. As the Tar accumulates, the Water is carried off, till the Reservoir is filled with Tar, when it is raised by pump into another Reservoir, whence it is conveyed to the Alembic, where ⅓ of it is distilled off, and what remains is thought Tar of the proper consistence. The matter distilled off is very pungent, and has been obtained of the colour of Mountain Wine, but they could not make it turn to any account; it was tried for Varnish without success. The water smells and

tastes strongly of *hepar sulphuris*, and has besides a peculiar pungency, which seemed to come from the oil; they had never ascertained the quantity of this water produced, and there was no appearance of its containing any volatile Alkali.

They also shewed us some Pitch, exactly like Lord Dundonald's. They said that they could not afford this Tar much cheaper than the foreign, on account of the great expence of casks for packing it up. It is used by the craft upon the Severn; many of the bargemen prefer it to every other kind, but others complain, that it being of a very penetrating Nature, is too soon absorbed by the Wood and Oakum, and exposes the vessels to grow leaky. They do not suppose any Tar comes over from the coal, till the smoke is of a thick yellow colour, the first smoke is chiefly waters. The communication pipes or tunnels between the chambers containing the coal, and the great tunnel for the vapour to be condensed, are furnished with a damper, that is a plate which can be occasionally shut down, when they have occasion to open the door of the chamber. If this door and the damper were up together, the distilling coal would be likely to take fire, and probably blow up the chamber. No elastic fluid was observed to escape; nor have they any apparatus to let it out, if any such should be generated. The Strata where they could be traced dipped down the River, inclining a little towards it. The hill a little above the Iron Bridge consisted almost entirely of Limestone, except a little towards the top, which was what they called dye earth, in which they observe no Iron stone or coal are ever found. This seems to be a clay laid on irregularly, so that the layers could scarcely be traced. In many places the separations between the layers of the Limestone were filled up with clay.

The part of the hill which had slid down into the Severn some years ago, appeared to consist of soft clay, together with some masses which had a stony appearance, but which softened in water, and were found to be clay like the former. That clay and the dye earth, were just of the colour of the Severn mud.

We returned to M^{r} Wilkinsons Forges at Willey by Broseley, to see the operation of shingling. The pig of Iron is in the finery converted into tough Iron, after which it is stamped in a sort of Iron pan, and then broken. These broken pieces with the small stuff which comes off in stamping, is put into the pots of yellow burnt clay, perhaps 9 or 10. inches in diameter, nearly as much in height, and cylindrical. These are placed in a Wind furnace, made to hold 18. of them at a time in 4. rows: that is 6. in the row behind, 5. in the next row forward, 4. in the next, and 3 in the nearest. Large lumps of coal are put to the side of each row, to prevent the flame from cutting off the Top of the pot, which it is apt to do. The fuel employed is raw coal. The fire in the Wind furnace was chiefly made at the side upon a grate; but there was a large space sideways with a solid floor, on which the pots stood, with a certain quantity of bright coal under them, and the funnel or chimney was continued up, still further sideways from behind the whole. They find a certain proportion of the small stuff absolutely necessary to the success of the operation. They call it cinders, and conceive that it not only assists in welding the different pieces of Iron together, but likewise enters into the Composition, and feeding the Iron. Their idea is, that the more cinders can be brought to unite with the Iron, of the better quality it becomes. When the pots are put into the fire, which they call charging, some of them crack very soon, others not till later, but all are cracked more or less during the operation,

not so however but they adhere together, keeping in the Iron in a lump, till the workman at the end of the operation, pulls them off from the lump with a hooked Iron, when they separate very easily, and are brought off in several pieces.

Toward the end of the operation, a hole toward the lower part of the solid floor, of the furnace, on which the pots stand, is opened from the cinders and coal which before stopped it up, and then a quantity of liquid Scoriae is seen running out for a considerable time, composed, as we were informed, partly of vitrified parts of the pot and coal, but partly also, perhaps principally, of matter which had run off from the Iron through the cracks in the pots. To facilitate the discharge of these Scoriae, the floor is made inclining a little from all parts toward the abovementioned hole. When the Furnace is to be drawn, the Term for taking out the pots, which is from 3 to 4. hours after it was charged, they begin by examining the appearance of the pots, and judge that they are fit, by the whole appearing of an uniform white heat. They then pull off the pot in pieces, as before mentioned, leaving the Iron it contained in the form of a cylindrical lump, which they call a ball. At the Chafery then an other workman makes the end of an Iron bar white hot, and when the first brings the white hot ball under the hammer, the latter lays the hot end of the Iron bar upon it, which is welded to it by a few strokes of the hammer, and then serves as a handle to turn and manage it. The hammer weighs about 6¼ C^{t} w^{t}. Its first effect is to strike off sparks, some of which fly to a great distance, and a few have the brilliant appearance of steel dust in fire works. There comes besides a white flame from different parts of the mass, and at times a different flame from certain spots, of a light bluish colour, like that from burning Sulphur. As the operation proceeded, some cinder ran down the Anvil, but in small quantity, and as the ball cooled, it assumed under the hammer an oblong angular form, 2 feet, or 18. inches in length, and perhaps 3 or 4. in thickness, and is then called a half bloom; which is afterwards drawn out in the Chafery, into a bar with *Maggot* ends, answering to the Blooms of Glamorganshire, here called an ancony. Some of them however appear to be drawn out in the first instance into uniform bars. Formerly the Iron was made without this operation of shingling; but then it was of much worse quality. The shingling properly means, beating the ball with a hammer; that of putting the iron into the pots to be heated, they call potting it.

By the Steam Engine at Rathbone's work, Coalbrook Dale, we saw a basket lying with several balls of fresh horse-dung: on enquiring the use, we were informed that they put it into the boiler of the Engine, when they observed any thing to leak out, and that it worked into the leak and stopped it.

We were told here and in other places, that they distinguished the goodness of the Iron produced by the Scoriae which come from the Furnace: those that are black rather spongy, and not very perfectly vitrified, indicate the best and toughest Iron. When the Scoriae comes out beautifully veined with white and blue, &c. such as we were shewn some at Willey Forge, the Iron is extremely bad. The general quality of the Iron produced at all these Forges, we were told was cold-short[4]; it is the quality of the ore, or mine to produce such, and they say positively that the same

[4] [Cold-short iron is brittle when cold.]

mine worked with charcoal, would make Iron still worse in this respect; but by the manner in which it crumbles in the operation of stamping, to produce the small stuff for the shingling pots, it appears clearly to be also in some degree at least, red-short.[5] Even under the shingling hammer, a great deal scales off, so that though it seems to be very strong in that state, yet it is not perfectly divested of its red-short quality. The breaking of the stamped Iron is effected by means of a strong iron plate, longer than broad, provided with ribs at proper intervals, set breadthwise: the stamped cake being laid upon [−−-] ribs, the workman strikes it with a sledge hammer on the part answering to the hollow, or interval between two ribs, when it commonly breaks off short, but sometimes only bends, and then must be laid upon the ribs with the convex side uppermost, when it always gives way to the stroke of the sledge.

About Bridgenorth on both sides of the Severn, we saw principally red rock, with a large proportion of sand: and it seemed to lie in all directions, or consisted of no regular Strata, for the lines or cracks sometimes ran one way, and sometimes another, in pieces that were close together. The Terras-walk commands a remarkable scene, from the singular appearance of these rocks all around, but especially on the opposite side of the River Severn, the Eastern, and from the fine view of the River underneath. The remains of the old Castle, battered by Oliver Cromwell, exhibit a remarkable instance of a leaning Tower, or ruin, which produces a fine effect. The Town is supplied with water from the Severn by means of wheel-work, turned by the current of the River, without any other fall than what is produced by stopping the current in that part and the height of great part of the Town above the River, is very considerable. We were told they had no other water.

Saturday August 6th 1785

In returning from Woolverhampton to Birmingham, about half way between Bilson and Wednesbury, we turned out of the way to the right 3 or 4 hundred yards to Bradley Furnace Forges, lately constructed by Mr Wilkinson. The road went close by the coal pit heath which has been burning many years. From some places close by the road, a strong flame was now issuing, and the earth seen through the crevices and apertures in many places was red hot or even white hot. All about the places actually burning, lay the cinders of old conflagrations, forming that reddish matter with which the road here is mended; and in many parts the ground had given way, forming hollows of greater or smaller diameter and more or less deep, on the edges or brink of which the ground was broken into long cracks of different width, some apparently very recent. The places from which the flame was now issuing, were not old pits, but apertures or cracks formed by the sinking down of the ground. About 3 years ago, the fire seemed approaching the Works at Bradley, and the ground became hot in many places; but it has been stopped by throwing upon the ground, at different times, considerable quantities of Water.

The Steam Engine at Bradley was upon Watt's construction, and made the blast by working the piston in a single cylinder, whence the Air was conveyed to a

[5] [Red-short iron is brittle when hot.]

Water-regulator, like that at Willey, but less. The Furnace here is 45. feet high, and 12. feet wide, at the Top of the boshes: flame issued from the Top of it. They use two kinds of ore, or mine, found on the spot among the coal, some above, some under, and some mixed with it. They do not distinguish the two sorts of Mine by different names, but use some of both, and find them both cold-short. They seem like the others a clay Stone impregnated with Iron, some pieces richly, but others poorly. They do not here cast any large things immediately from the Furnace, but carry the pigs to a foundry where there are several hearths, with Machinery of cranes, &c. They bring the streams from these several hearths to join in one, when the piece to be cast requires so great a quantity of Metal. These hearths were all wind Furnaces, with the fire made at one side.

At Bradley we had a further account of the Finery hearth. The bottom plate from 18 inches to two feet square, serves as the top to a cistern of water beneath the hearth, supplied with a small stream of water, which runs in and out through the cistern. The surface of the water is kept 3 or 4. inches below the bottom of the plate, which is interposed between it and the Metal in the hearth; that is, the bottom plate of the hearth: and its use is to keep that place cool, as they suppose. We observed that the shingling Furnace had a small pit at the hole through which the Scoriae are discharged, toward which pit the floor supporting the pots inclines on all sides. The Steam Engine here worked with the rod of the piston quite dry, and made no pause at beginning to lift. We saw a fly-wheel of Iron lately cast, and observed that the circumference was not continued, though the whole was cast at once, and the center and spokes were one: the separation in the circumference was in the middle between each spoke, and was left that it might not give way of itself in cooling, by the unequal contraction of the spokes and circumference. At the edges of the separation on each side were holes, for joining them together by means of an Iron plate to which each edge was to be fastened: thus the whole was stronger that it would have been likely to be if a single piece.

The rolling and slitting Mill was worked with a Steam Engine, which communicated a circular Motion by means of a crank. There were two wheels of cast Iron turning on separate axes, very near each other: each wheel having round its circumference a number of large holes, into which entered a large Iron pin, which passed through the hole or loop at the end of the rod. Thus the rod moved both these wheels round, keeping between them, & could thereby communicate movement to two different sets of Machinery. Each wheel turned the pinion of a large fly-wheel, by means of which the proper action of the crank was answered. The fly was not loaded on one side. Each of these wheels was made to turn a rolling and slitting Mill; but one set only was finished. The two cylinders of the Rolling Mill were inclined to each other, and adjusted to four gradations, so that the bar was rolled 4 times with the same heating. After being passed through the widest part, it was received by a workman on the opposite side, and conveyed over again to the first workman, who then passed it through the second gradation, and so on for the 3^{d} and 4th gradation, by which time it was reduced to a bar of considerable length, about 1/2 an inch thick, from a not more than a foot or 9 inches long, and

perhaps 2. inches square. To make these, they hammer out a half bloom to the proper thickness, and then cut in into such lengths, which they call, As soon as it had passed through the rollers, it went to the slitting Mill without any other heating, and there cut into rods for nails.

Mr. Watt has contrived a Furnace to burn the Smoke, which he means to apply to the Steam Engine. The draught of Air is conducted backward.